`THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**STORMWATER TREATMENT TECHNOLOGY**	
APPLICATION:	**SUSPENDED SOLIDS TREATMENT**	
TECHNOLOGY NAME:	**DOWNSTREAM DEFENDER®, 6-ft DIAMETER**	
TEST LOCATION:	**MADISON, WISCONSIN**	
COMPANY:	**HYDRO INTERNATIONAL**	
ADDRESS:	**94 Hutchins Drive** **Portland, Maine 04102**	PHONE: **(207) 756-6200** FAX: **(207) 756-6212**
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NSF International (NSF), in cooperation with the U.S. Environmental Protection Agency (EPA), operates the Water Quality Protection Center (WQPC), one of six centers under the Environmental Technology Verification (ETV) Program. The WQPC recently evaluated the performance of a 6-ft Downstream Defender®, manufactured by Hydro International. The Downstream Defender® was installed at the Madison Water Utility in Madison, Wisconsin. Earth Tech, Inc. and the United States Geologic Survey (USGS) performed the testing.

EPA created ETV to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The ETV program's goal is to further environmental protection by accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer-reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups, which consist of buyers, vendor organizations, and permitters; and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

TECHNOLOGY DESCRIPTION

The following description of the Downstream Defender® was provided by the vendor and does not represent verified information.

The Downstream Defender® is a hydrodynamic vortex separator designed to remove settleable solids (and their associated pollutants), oil, and floatables from stormwater runoff. It consists of a cylindrical concrete vessel, with plastic internal components and a 304 stainless steel support frame and connecting hardware. The concrete vessel is a standard pre-cast cylindrical manhole with a tangential inlet pipe installed below ground. Two ports at ground level provide access for inspection and clean out of stored floatables and sediment. The internal components consist of two concentric hollow cylinders (the dip plate and center shaft), an inverted cone (the center cone), a benching skirt, and a floatables lid.

The Downstream Defender® is self-activating, and operates on simple fluid dynamics. The geometry of the internal components and placement of the inlet and outlet pipes are designed to direct the flow in a pre-determined path through the vessel. Stormwater is introduced tangentially into the side of the vessel, initially spiraling around the perimeter in the outer annular space between the dip plate cylinder and manhole wall. Oil and floatables rise to the water surface and are trapped by the dip plate in the outer annular space. As the flow continues to rotate about the vertical axis, it travels down towards the bottom of the dip plate. Low energy vortex motion directs sediment toward the center and base of the vessel. Flow passes under the dip plate and up through the inner annular space, between the dip plate and center shaft, as a narrower spiraling column rotating at a slower velocity than the outer downward flow. The outlet of the Downstream Defender® is a single central discharge from the top water level in the inner annulus.

Performance of the Downstream Defender®, in terms of sediment removals, depends on the incoming flow rate, particle size distribution, specific gravity, and runoff temperature. According to Hydro International, for runoff at 15 C°, the Downstream Defender® will remove over 80% of settleable solids with a specific gravity of 2.65 and a particle size distribution similar to Maine DOT road sand at flow rates up to 3 cfs. Flows exceeding the design capacity (3 cfs for the tested system) would be bypassed by a weir system installed upstream of the Downstream Defender®.

VERIFICATION TESTING DESCRIPTION

Methods and Procedures

The test methods and procedures used during the study are described in the *Test Plan for the Verification of. Downstream Defender® "Madison Water Utility Administration Building Site" Madison, Wisconsin September 30, 2005*. The Downstream Defender® was installed to treat runoff collected from a paved parking area at the Madison Water Utility in Madison, Wisconsin. Madison receives an average annual precipitation of nearly 33 in., with an average snowfall of 44 in.

Verification testing consisted of collecting data during a minimum of 15 qualified events that met the following criteria:

- The total rainfall depth for the event, measured at the site, was 0.2 in. (5 mm) or greater;
- Flow through the treatment device was successfully measured and recorded over the duration of the runoff period;
- A flow-proportional composite sample was successfully collected for both the inlet and the outlet over the duration of the runoff event;
- Each composite sample was comprised of a minimum of five aliquots, including at least two aliquots on the rising limb of the runoff hydrograph, at least one aliquot near the peak, and at least two aliquots on the falling limb of the runoff hydrograph; and
- There was a minimum of six hours between qualified sampling events.

Automated sample monitoring and collection devices were installed and programmed to collect composite samples from the inlet, system outlet, bypass, and combined discharge (system plus bypass) during qualified flow events. In addition to the flow and analytical data, operation and maintenance (O&M) data were recorded. Samples were analyzed for total suspended solids (TSS), suspended sediment concentration (SSC), total dissolved solids (TDS), volatile suspended solids (VSS), and particle size distribution. The TSS analytical method was modified for samples with a heavy settleable sediment load using a procedure developed by USGS. The adjusted TSS method was designed to provide an improved methodology for measuring large, dense sediment particles in samples. Refer to the verification report for additional details about the modified TSS method.

VERIFICATION OF PERFORMANCE

Verification testing of the Downstream Defender® lasted approximately 17 months, and coincided with testing conducted by USGS and the Wisconsin Department of Natural Resources. A total of 20 storm events were sampled.

Test Results

The precipitation data for the rain events are summarized in Table 1. Peak flow rates exceeded the rated treatment capacity of the Downstream Defender® during events 5, 6, 19 and 20. These events were large and intense, and it appeared that runoff from an adjacent drainage area may have contributed additional flow and organic solids loading to the unit during these events.

The monitoring results were evaluated using event mean concentration (EMC) and sum of loads (SOL) comparisons. The EMC evaluates treatment efficiency on a percentage basis by dividing the outlet concentration by the inlet concentration and multiplying the quotient by 100. The EMC was calculated for each analytical parameter and each storm event. The SOL comparison evaluates the treatment efficiency on a percentage basis by comparing the sum of the inlet and outlet loads (the parameter concentration multiplied by the runoff volume) for all storm events. The calculation is made by subtracting from one the quotient of the total outlet load divided by the total inlet load, and multiplying by 100. SOL results can be summarized on an overall basis since the loading calculation takes into account both the concentration and volume of runoff from each event. The analytical data ranges, EMC range, and SOL reduction values are shown in Table 2.

The ratio of organic sediment to total sediment was measured by evaluating the ratio of VSS to TSS or SSC. This ratio showed a median organic sediment loading of 21% over all events, with a range of 4.7% to 67% during individual events. Organic materials, which include grass or leaf debris, are less dense than inorganic sediments, such as soil. The vendor claims that the Downstream Defender® is not as effective at removing lower-density organic solids from runoff.

A particle size gradation was conducted to quantify percentage (by weight) of particles ranging from >500 µm to <2 um, and the SOL was recalculated based on particle sizes. The particle size distribution of the sediments encountered at this site was significantly finer than the Maine DOT road sand and F-110 Silica Sand which formed the basis of product claims. For the range of solids encountered at this site, the Downstream Defender® removed 90% of particles larger than 250 µm on a cumulative basis. As shown in Table 3, the Downstream Defender® removed 78% of the particles greater than 125 µm and 67% of the particles greater than 63 µm on a cumulative basis.

System Operation

The Downstream Defender® was installed prior to verification, so verification of installation procedures on the system was not documented. It was thoroughly cleaned prior to the start of verification testing.

The Downstream Defender® was inspected periodically during verification, and no significant issues were noted. By the end of the verification test, the sediment chamber contained sediment at an approximate average depth of 0.35 ft. A particle size distribution analysis conducted on the retained solids showed that approximately 93% of the retained solids were 125 μm or larger. No specific gravity analysis was conducted for the captured solids; however, visual inspections suggested significant organic content. The dry weight of the retained solids was 416 pounds.

Table 1. Rainfall Data Summary

Event Number	Date	Start Time	Rainfall Amount (in.)	Rainfall Duration (hr:min)	Runoff Volume (ft^3)[2]	Peak Flow Rate (cfs) [2]	Water Temp. (°C)
1	3/8/06	18:03	0.71	4:36	1,880	1.0	3.5
2	3/12/06	18:34	0.43	9:25	1,370	0.42	4.6
3	4/2/06	20:41	1.01	10:01	5,910	0.38	15.5
4	4/12/06	5:07	0.37	2:56	1,980	0.63	--[3]
5[1]	4/16/06	4:15	1.13	12:44	6,230	5.8[1]	--[3]
6	4/29/06	17:18	1.65	25:38	8,480	0.66	--[3]
7	5/1/06	21:16	0.25	0:26	1,570	2.0	---[3]
8	5/9/06	12:01	0.37	6:50	2,090	0.35	15.4[4]
9	5/11/06	6:59	0.86	23:55	5,040	0.18	10.5[4]
10	5/17/06	15:36	0.23	2:02	1,310	0.85	14.8[4]
11	6/25/06	17:34	0.79	15:41	4,250	0.67	19.0[4]
12	7/9/06	19:45	0.36	0:08	1,430	2.6	24.8[4]
13	7/11/06	8:44	1.87	8:51	10,990	1.5	20.7[4]
14	7/19/06	21:43	0.96	9:44	4,680	2.5	22.8[4]
15	7/22/06	16:51	0.36	0:30	1,860	1.9	23.0[4]
16[1]	7/27/06	12:27	2.16	1:30	7,150	6.5[1]	24.0[4]
17	8/6/06	6:53	0.71	5:08	3,630	0.50	23.4[4]
18	8/17/06	16:27	0.29	1:45	1,300	1.3	22.4[4]
19[1]	8/23/06	23:06	1.60	8:17	13,450	4.4[1]	22.4[4]
20[1]	8/24/06	13:30	1.35	2:13	17,180	4.6[1]	22.8[4]

1. Peak flow capacity was exceeded and bypass flows were sampled.
2. Runoff volume and peak discharge rate measured at the inlet monitoring point. See the verification report for further details.
3. Temperature not recorded due to equipment malfunction.
4. Water temperature recorded at a nearby stormwater sampling site monitored by Wisconsin Department of Natural Resources.

Table 2. Analytical Data, EMC Range, and SOL Reduction Results

Parameter	Inlet range (mg/L)	Outlet range (mg/L)	EMC range (%)	SOL reduction w/o bypass (%)	SOL reduction all events inc. bypass (%)
TSS	23 – 700	19 – 584	-51 – 62	27	22
SSC	22 – 904	21 – 662	-47 – 70	42	33
TDS	<50 – 260	<50 – 238	-163 – 55	1	1
VSS	9 – 76	10 – 76	-82 – 19	-7	-6

Table 3. Sediment Sum of Load Results by Particle Size Category

Particle Size Category (µm)	DD Inlet (lb)	DD Outlet (lb)	Bypass (lb)	Individual Particle Size Load: DD Efficiency (%)	Individual Particle Size Load: System Efficiency (%)	Cumulative Particle Size Load: DD Efficiency (%)	Cumulative Particle Size Load: System Efficiency (%)
> 500	453	39	32	91	85	91	85
250-500	449	49	58	89	79	90	82
125-250	150	146	49	3	2	78	69
63-125	128	156	56	-2	-15	67	58
32-63	122	122	31	0	0	61	52
14-32	517	550	164	-6	-5	42	34

Quality Assurance/Quality Control

NSF personnel completed a technical systems audit during testing to ensure that the testing was in compliance with the test plan. NSF also completed a data quality audit of at least 10% of the test data to ensure that the reported data represented the data generated during testing. In addition to QA/QC audits performed by NSF, EPA personnel conducted an audit of NSF's QA Management Program.

Original signed by
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Availability of Supporting Documents

Copies of the *ETV Verification Protocol, Stormwater Source Area Treatment Technologies Draft 4.1, March 2002,* the verification statement, and the verification report (NSF Report Number 07/31/WQPC-WWF) are available from:

ETV Water Quality Protection Center Program Manager (hard copy)
NSF International
P.O. Box 130140
Ann Arbor, Michigan 48113-0140

NSF website: http://www.nsf.org/etv (electronic copy)
EPA website: http://www.epa.gov/etv (electronic copy)
Appendices are not included in the verification report, but are available from NSF upon request.